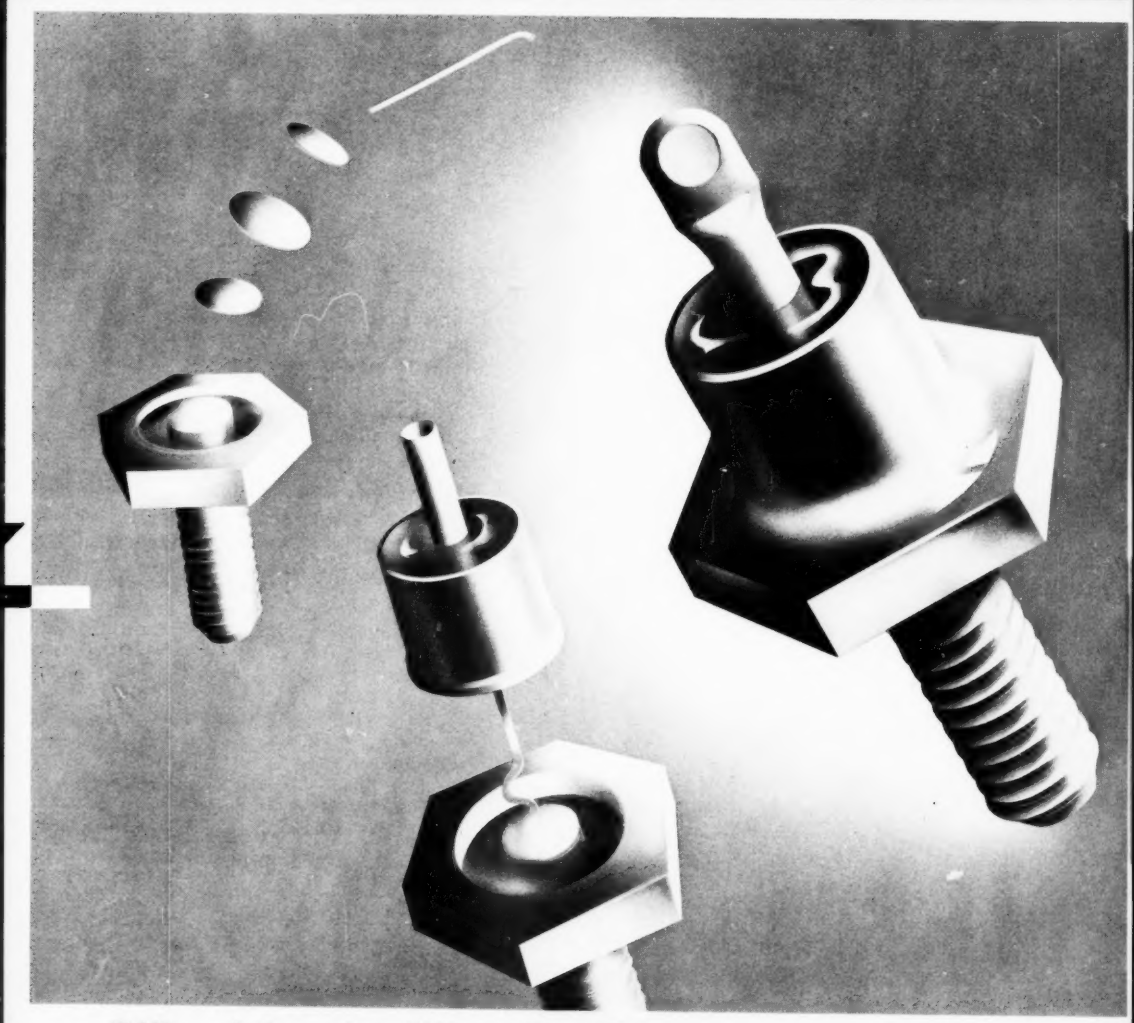
RAYTHEON

ELECTRONIC PROGRESS

DECEMBER 1956



Diffused Junction Silicon Rectifier

In this issue: SEMICONDUCTOR DIODES

ELECTRONIC PROGRESS

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RAYTHEON

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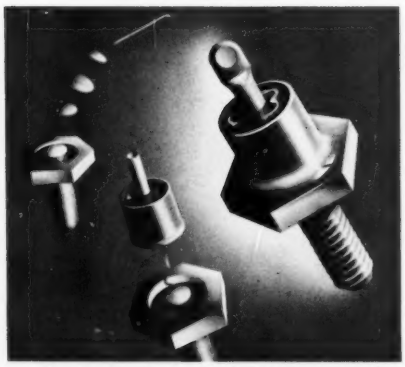
THE COVER



The diffused junction silicon rectifier depicted on our cover consititutes a new step forward in the art of semiconductor technology. This diode, along with present day point contact, bonded and alloy junction types, represents great scientific advancement from the early days of the galena crystal with its critical catwhisker. Born of a need in the radar program of World War II, today's semiconductor diodes are everywhere challenging their vacuum tube counterparts, and, in many instances, are making possible entirely new types of circuitry.

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Calendar

Northeastern University Off-Campus Courses

	Place	*Time and Date*
Transistor Circuit Engineering	Training Center Waltham	Monday, 6-8 P.M.
Theoretical Physics	Training Center	Tuesday, 6-8 P.M.
Radar Engineering	Wayland	Tuesday, 6-8 P.M.
Physics of Semiconductors	California Street	Wed., 6-8 P.M.
Transients in Linear Systems	Training Center	Wed., 6-8 P.M.
Principles of Microwave Tubes	Training Center	Thurs., 6-8 P.M.
Advanced Mathematics I	Training Center	Friday, 6-8 P.M.
Advanced Mathematics II	Research	Friday, 6-8 P.M.

For information call Robert C. Story, Extension 495, Waltham

Other Seminars and Courses

Space Charge Seminar	Research	As required
Ceramics Seminar	Research	As required
Welding Engineering	South Waltham Junior High School	Each Tuesday at 6:00 P.M.
High Frequency Semiconductor Devices — H. Statz		Tues. Nov. 13*
Sublattice Effects in Ferromagnetic Resonance — E. Schlomann		Wed. Nov. 28*
Backward Wave Tubes — E. Dench		Wed. Dec. 12*
Semiconductor Surfaces — G. deMars		Wed. Jan. 9*

**Place and Time — Wayland Cafeteria 5:20 p.m.*

Technical Committee Meetings

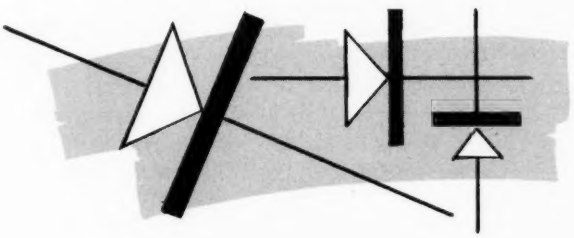
	Place	*Time and Date*
Plastics	Varies	2nd Tues. or Thurs. of the month
Ferrite	Varies	1st Wed., of the month at 3:00 P.M.
Transistor Circuit	Research	As required
Welding	Varies	1st Thurs. of the month at 3:00 P.M.
Magnetic Amplifier	Wayland Laboratory	November 6
Engineering and Scientific Co-ordinating Committee for Digital Computers	Research	As required

Technical and engineering personnel who desire further information concerning the above calendar should contact Mr. James Sterling, Research Division, Extension 2187.

The New Look in Diodes

FRANK FINNEGAN and GERALD HUGHES

Semiconductor Division
Receiving and Cathode Ray Tube Operations



The trend in new electronic equipment is toward miniaturization while maintaining good performance over a wide range of environmental conditions. Raytheon's new and recently announced medium power diffused junction diode now enables equipment manufacturers to obtain higher thermal and volumetric efficiency than has been possible up to this time. Relative size of the six new pigtail types, (CK840, 841, 842, 843, 844, and 845) and the four new stud-mounted types, CK846, 847, 848, and 849) can be seen in Figure 1. In addition to small size and higher current and voltage ratings, the revolutionary fabrication process allows more accurate prediction of final characteristics plus a significant increase in reliability and, therefore, extended operational life.

A pictorial comparison of the fused (or alloy) type construction and the new diffused type construction is shown in Figure 2. It can be seen from the picture that the fused junction, which is formed at high temperatures in a relatively short period of time, is concentrated (with sharply varying gradients) more in one spot on the semiconductor chip than the new diffused junction, which has a much larger area and possesses a more uniform gradient of impurity concentration. A diffused chip, which is processed over a longer diffusion doping time and under more easily controlled ambient conditions, has therefore, a more uniform and predictable depth of doping penetration, gradient, and base width. The more accurately controlled characteristics of the diffused diode result in more uniformity in production, thus simplifying rectifier circuit design and stabilizing actual operation for the equipment manufacturer.

Preparation of the semiconductor chip by solid state diffusion is a relatively lengthy and complex process compared to the usual method of alloy fusion. The additional processing time, however, does allow more accurate control of the physical properties of the semi-conductor material.

The mechanics of solid-state diffusion consist of first obtaining carefully cleaned slices from appropriate semiconductor crystals and subjecting them to an extremely high temperature for a pre-determined number of hours. During the heat run, a small amount of doping impurity in the form of vapor is diffused into the semiconductor material. The depth of penetration by diffusion of the impurity is controlled by the length of time the slices are at high temperature. A more exhaustive treatment of the factors governing diffusion processes may be

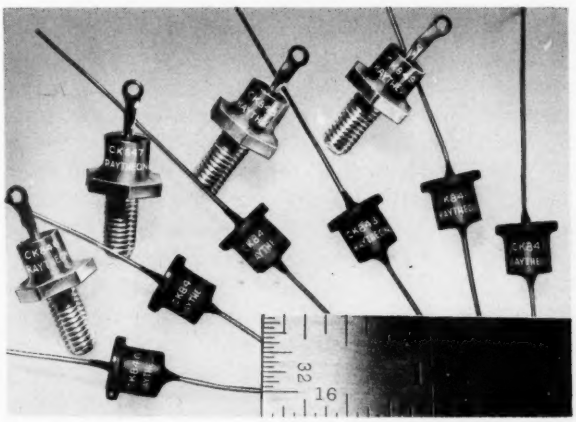


Figure 1

found in many books and technical papers.

Upon removal from the diffusion ovens, the slices are cleaned and their surfaces specially treated so that diodes made from them are capable of having very low resistance lead and base contacts.

The basic package for this medium power diode is a glass-to-metal header welded to a metal base as can be seen in Figure 3. Assembly of the internal parts begins with the preparation of a chip of silicon, both sides of this chip being specially treated to

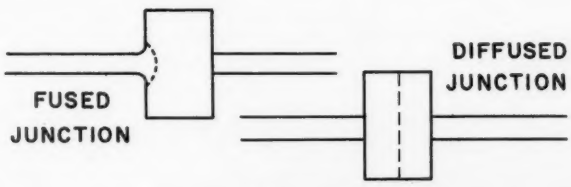


Figure 2

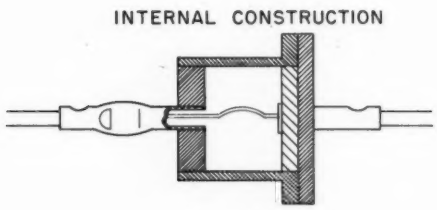


Figure 3

enable low-resistance, non-rectifying contacts to be made and thus making possible the high forward conduction characteristics of this type diode.

The chip of silicon is soldered to the metal base of the diode package. The anode lead wire is next soldered to the top of the chip. Before the header is connected to the base, the assembled diode is cleaned and put in a controlled atmosphere where it stays until the header to base weld is made and the anode lead opening is sealed off.

Although the new type diodes are rated at 350 ma. (full cycle average) with a forward drop of 0.75 volts (full cycle average), the average in production has been better than this. The reverse characteristics obtained have been equally satisfactory, with peak inverse voltages obtained over the ranges specified on the data sheets for the various types indicated. Static reverse currents of the diffused diodes have been well under one microampere at 80% of the peak inverse voltage at room temperature. The reverse current specification on these diodes is an average value, averaged over a complete cycle, since this is a customary manner in which to specify leakage current in a diode whose primary use will be as a low frequency rectifier.

Typical dynamic characteristics and their variation with temperature for the CK845 are shown in Figure 4. The high back resistance and the relatively

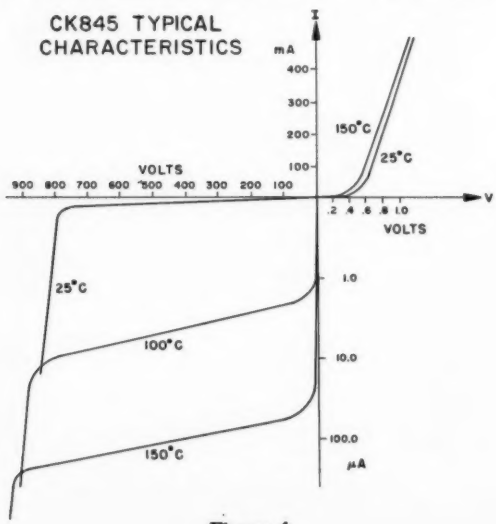


Figure 4

sharp breakdown region are typical properties of a good quality silicon junction diode. The superior forward characteristic is the result of the process.

As examples of maximum ratings, the CK845 has a peak inverse voltage of 600, and average forward currents of 350 ma. at 100°C and 100 ma. at 150°C. The average forward voltage drop at 350 ma. and 100°C is 0.75 volts. The maximum average reverse current at 100°C and 420 volts, RMS into an inductive or resistive load is 0.2 ma. Comparable values for the CK849 are 600 PIV, 3000 ma. (100°C) and 1000 ma. (150°C) average forward currents.

The family of stud-mounted diodes is similar to the wire-in type discussed above. The construction differs in that a slightly larger chip, a different lead wire, and, of course, the different package, are used.

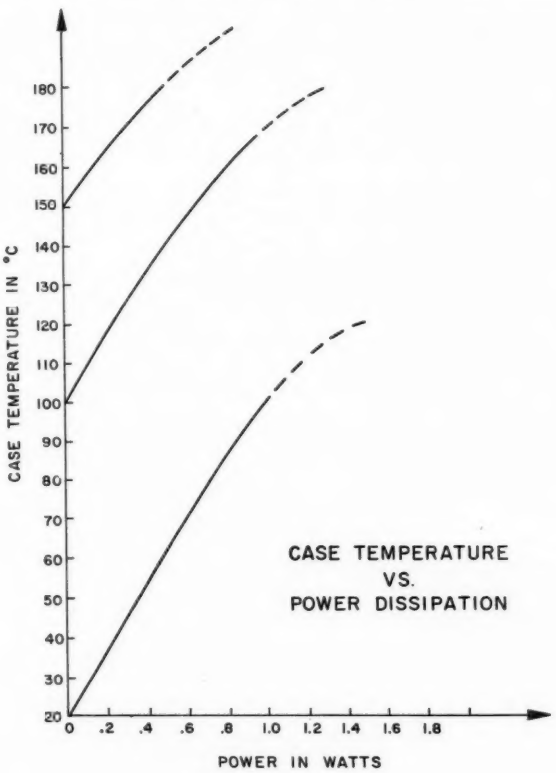


Figure 5

These diodes are easily attached to heat sink arrangements. The allowable dissipation of this family is primarily related to the case temperature which can be maintained under a wide variety of environmental and heat sinking arrangements.

The specifications for the CK840 family allow storage temperatures from —65°C to 175°C.

Under all operating conditions the internal junction temperature must be held to a maximum of

175°C. The temperature rise of the diode due to electrical losses establishes the power dissipation and hence the maximum ratings under the various operating conditions. Figure 5 gives the relation of case temperature to power dissipation for diodes of the wire-in family. The actual junction temperature may be quickly obtained knowing that the junction to case thermal resistance is approximately 4 degrees C per watt. This figure has been obtained theoretically and experimentally. It should be noted that the internal thermal resistance results from the electrical analogy of a thermal configuration when temperature is related to voltage, heat flow in watts is analogous to current, and thermal resistance becomes the temperature difference per watt dissipated. (°C per watt.)

The average current ratings and derating factor of 5 ma per °C above 100°C were established knowing the temperature-power relations and the characteristics of a rectifier just falling inside the specification limits. Somewhat higher ratings are allowable under forced air cooling or adequate heat sink arrangements. The ratings as given apply to a diode suspended in free air where the cooling mechanisms are conduction, convection, and radiation. The finished diodes are given a black paint coat to increase heat loss by radiation and to provide a uniform appearance.

Individual data sheets giving more detailed information for each of the types described are available on request. These data sheets as well as availability information can be obtained from the Semiconductor Diode Sales Office, 150 California St., Newton 58, Mass.

Semiconductor Diodes

W. B. MITCHELL

Semiconductor Division
Receiving and Cathode Ray Tube Operations

The relative simplicity of the diode as compared with other electronic active circuit elements has led, paradoxically, to its misuse in a number of different applications. In part, this is due to the fact that engineers tend to visualize a diode as a perfect switch. For a vacuum tube in a high impedance circuit this is often true, but a semiconductor diode will not always exhibit this ideal characteristic. For example, where a vacuum tube diode may have a leakage current much less than a microampere, in many semiconductor diodes the leakage may approach a milliampere, or in the case of high power rectifiers, many milliamperes! These values mean little when considered separately; the important criterion is the ratio of the front to back conductance. In other words, in a circuit which passes 50 μa through the diode in the forward direction, a reverse current of 10 μa would be unreasonable. In a power application in which the diode carries a forward current of 5 amperes, a leakage current of 10 ma. or more may easily be tolerated in the circuit.

Because of the wide range of both forward and reverse resistances presently available in semiconductor diodes, some specifications based on these particular parameters are necessary. Due to the nonlinearity of the current-voltage characteristic, the resistance varies with the operating point. Thus, it is common practice to specify the forward current at some voltage, normally +1.0 volts, and the reverse current at one or more points, —10 volts usually being one of these. As an example, a bonded silicon diode might be specified as follows: a minimum forward current of 20 milliamperes at +1.0 volts, and a maximum reverse current of 0.01 microamperes at —10 volts, rising to 0.1 microamperes at —50 volts.

One of the unfortunate characteristics of a semiconductor diode is its variation with temperature. The reverse leakage current in most diodes will double for every 10°C temperature rise. This brings up the problem of rating a diode at elevated temperatures. When a diode is conducting, there is an IR drop and, consequently, a heating effect. This raises the temperature of the diode and therefore increases the leakage which will tend to cause more heating — a vicious bootstrap effect. Actually, the diode may easily destroy itself if the temperature is not limited to some fixed value, either by better heat transfer (such as a heat sink) or by sufficient derating. At the present time, the maximum temperature for germanium is about 100°C; for silicon, 200°C. The necessary derating curves are given on the data sheets describing the diode. Any excess heating may destroy the diode and will certainly reduce the life of the unit.

The limitations of semiconductor diodes which have thus far been discussed have to be considered by the design engineer who may be overeager to capitalize on the significant advantages that these devices seem to offer. Small size, ruggedness, very long life (theoretically infinite) and the absence of filaments are some of the advantages that have been

well publicized. Perhaps not so well known are the facts that the capacitance of the semiconductor diode can be made lower than its vacuum tube counterpart (less than 0.5 μμf in some units), or that the forward drop for a given current is generally much lower than in vacuum tubes. This can be extremely important in the case of very high current rectifiers, where the power losses due to the drop in the tube may be prohibitive. With semiconductor diodes the efficiency may well exceed 99 per cent.

Having thus been warned, the circuit designer begins on a problem by specifying the forward and reverse DC characteristics, power dissipation, temperature derating, etc. Let us say that it is then desired to take a one megacycle per second square wave, remove the negative portion and allow the positive part to pass. The normal approach to the problem is to construct a circuit as shown in figure 1.

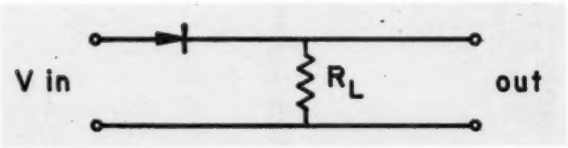


Figure 1

In order to get the least attenuation of the signal, a diode with a high forward conductance and sufficient reverse requirements has been specified. However, when the diode is tried in the circuit, instead of getting an output as shown in figure 2A, a wave shape as shown in 2B is much more likely. The question arises as to what is causing this spike.

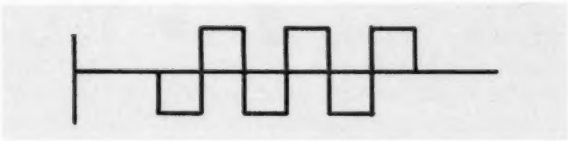


Figure 2A

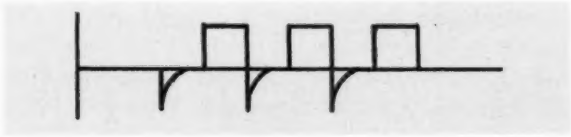


Figure 2B

Due to the fact, that in a semiconductor diode the conduction takes place not in a vacuum, but inside of a crystalline solid, the velocity of the carriers is not as great as in a vacuum tube and therefore, they take more time to be swept out of the junction. It is these carriers which give a reverse current as they are swept out by the reverse bias. This reverse transient response is generally a function of the diode junction area. The smaller the area, the faster the diode will recover, and the higher the frequencies at which the diode will operate. For this reason, circuits requiring diodes to operate at frequencies much above 1.0 mc will generally require point contact diodes as opposed to fused, or bonded diodes. A typical static characteristic curve for a 1N67 point contact diode is shown in figure 3.

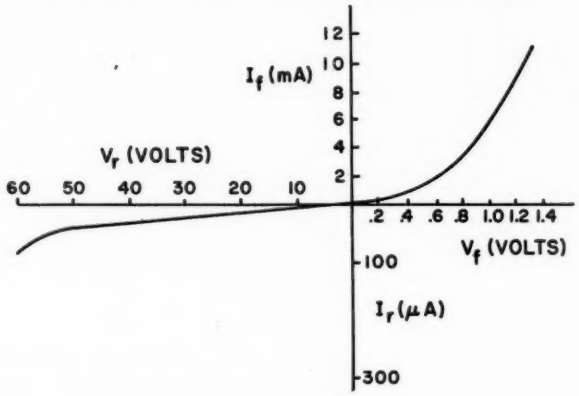


Figure 3

Figure 4 shows the reverse transient response for a 1N67 when swept from 30 ma. in the forward direction to —35 volts in the reverse.

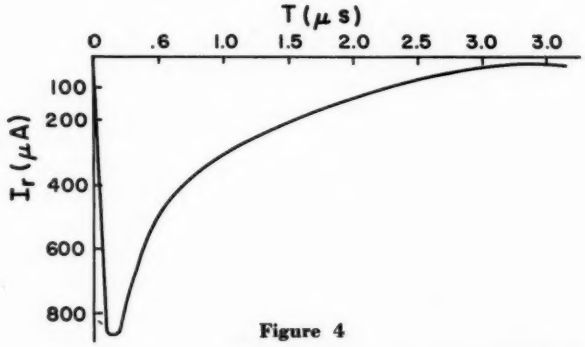


Figure 4

Consider now an application where a positive pulse must be shunted to ground and a negative pulse allowed to pass. The circuit of figure 5A would seem reasonable for this requirement, but its output might look like the waveform shown in figure 5B.

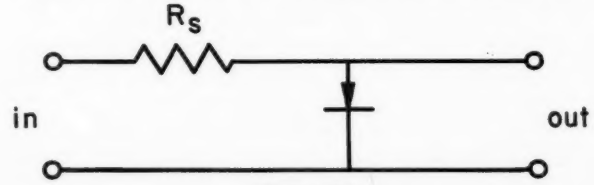


Figure 5A

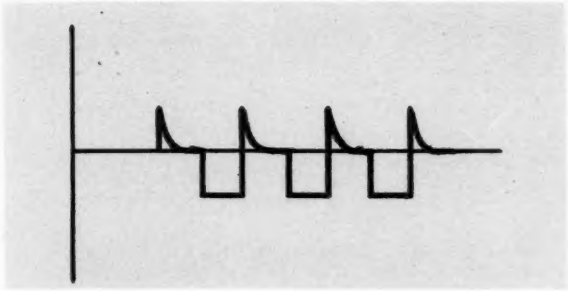


Figure 5B

This phenomenon is due to the fact that a semiconductor diode does not begin conducting at the exact instant of forward voltage application, but at first offers a relatively high resistance and then approaches its static conductance. The time for most diodes to recover to the static value is of the order of 0.1 usec. Actually, the peak voltage across a diode when a constant current pulse is applied, may be two or three times the static voltage drop for the same current. A point contact diode will generally have a rather poor forward transient response as compared to a bonded or fused diode. Thus, the diode that worked well in circuit 1 will not suffice for this application. In this case, a bonded diode will be used with a forward transient response as shown in figure 6. This is a plot of voltage versus time after the application of a pulse of a specified current.

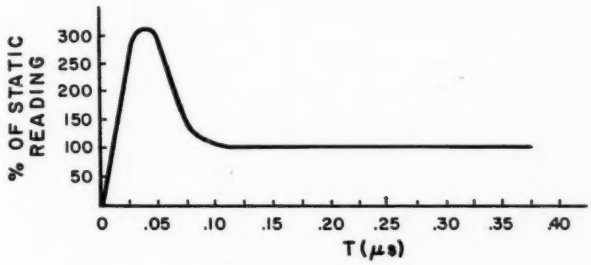


Figure 6

Another problem which often occurs is the rectification of a very low level signal. At levels below 50 millivolts, a diode does not rectify, but simply acts as a resistor. The solution is to bias the diode away from the origin into the conducting region. This generally requires a sensitive balancing arrangement, but it can be done in this manner.

The actual number of applications of diodes is far too great to cover in detail, but two specialized applications will be mentioned here. One is based on the fact that silicon diodes can be constructed so as to exhibit a characteristic as shown in figure 7.

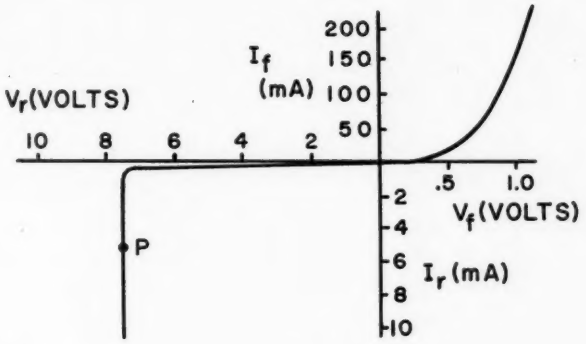


Figure 7

A diode of this type, when operated around point "P" makes a fine voltage reference or regulator. With proper circuitry, one of these reference or "Zener" diodes can be made to provide a stable voltage with a temperature coefficient as low as 0.0005 per cent per °C.

The use of diodes in special wave-shaping networks is the basis for a second example. The log-shaping network shown in figure 8 is perhaps the

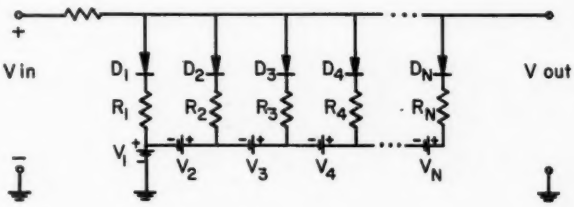


Figure 8

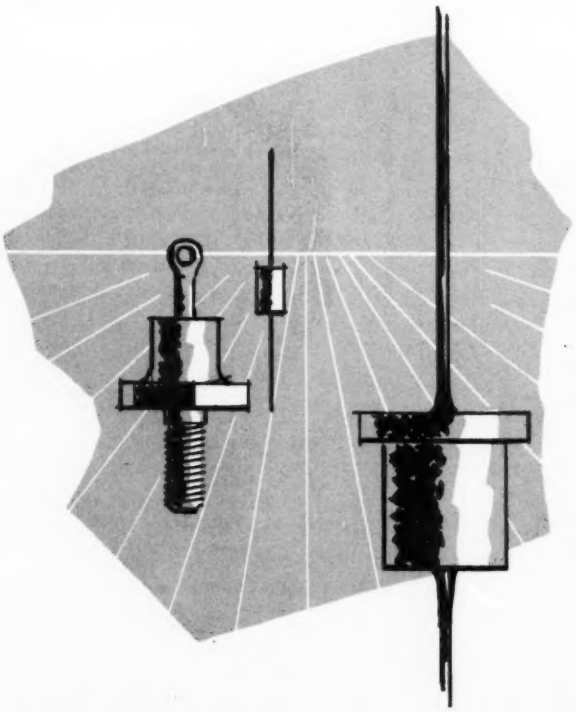
most common of this type of application. In this circuit, diode #1 will begin conducting at a certain present voltage, giving a load impedance of R_1 (assuming R_1 is large as compared to the diode resistance). As the input voltage is increased, a point will be reached at which diode #2 will conduct. This will then give a different load resistance, which will be the value of R_1 and R_2 in parallel. As many diodes as desired may be strung across the line; the more used, the greater the range. Although in this circuit, the output voltage is the logarithm of the input voltage, the output curve may be made to approximate a great many different functions of the input through the proper selection of the various voltages, resistors and diodes. Such networks are valuable elements in analog computers, as well as in many other equipments.

To act as a summary and also to give some idea of which diode is most suited to a particular application, Table I is presented below.

Application	*Type*	*Special Characteristics*	*Possible Problems*
1. Low power rectifier.	P.C., B.G., B.S.	Reasonable static characteristics, sufficient P.I.V. and current handling capabilities.	P.I.V. exceeded due to surges, high surge currents due to capacitive load and ambient temperature too high.
2. High power rectifier.	Fused Ge, fused Si and diffused Si.	High forward conductance and good thermal properties.	Excessive heating, current and voltage surges and matching diodes in multiphase circuits.
3. Medium frequency detector to 1.0 mc.	P.C., B.G., B.S.	Reasonable transient responses, low capacitance and good front to back resistance ratio.	Input signal too low, load capacitance and resistance not correct.
4. High frequency detector.	P.C.	Very good transient responses, low capacitance, good front to back resistance ratios at the applied voltages.	Input signal too low, load capacitance and resistance not optimum.
5. Clamps and gates, etc.	P.C., B.G., B.S.	Good transient responses, proper static characteristics and low noise sufficient to handle surges applied.	Transient response too slow and change of static characteristics due to temperature variations.
6. Regulators and references.	B.G. and B.S.	Avalanche or "Zener" breakdown at proper voltage. Ability to handle required current, good temperature characteristics and low impedance in "Zener" region.	Noisy knee, unstable breakdown region due to excessive heating, improper temperature compensating and operation at wrong D.C. level.
7. Multiple assemblies.	P.C., B.G., B.S., fused Ge, fused Si and diffused Si.	Matching of diodes to proper tolerances and uniform variation of characteristics with temperature among units of an assembly.	Improper initial matching, allowable ratings exceeded and heat gradient across assembly.

a) P.C. = Point Contact Diode (such as 1N67, 1N69, etc.)
b) B.G. = Gold Bonded Germanium Diode (such as 1N305, 1N307, etc.)
c) B.S. = Bonded Silicon Diode (such as 1N300, 1N302A, etc.)
d) Fused Ge = Fused Germanium Diode (such as 1N91, 1N93, etc.)
e) Fused Si = Fused Silicon Diode (such as CK775, CK776, etc.)
f) Diffused Si = Gaseous Diffused Silicon Diode (such as CK840, CK843, etc.)

TABLE I



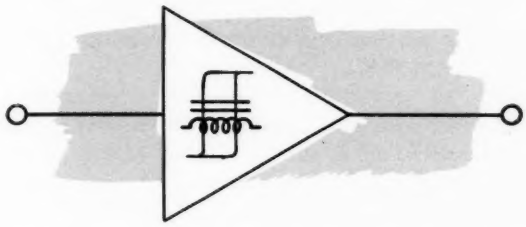
Inventions

Congratulations to the following persons for their valuable contributions to Raytheon's portfolio of inventions:

Name	*Field of Invention*
Ahearn, J. F.	Gaseous Cooling System
Cole, B. R., Cleary, R. W.	Limiter
Haagensen, D. B., Buoymaster, N. W.	Cardiograph Stylus
McLeod, W. W., Jr.	Oscillator Locking Device
Morin, R. H.	CR Tube Processing Apparatus
Rainis, A. V., Arsenault, J. R.	Welding Current Control System
Sheldon, E. J., Cole, B. R.	Relay Control Circuit
Spyut, A. B.	Sealing Method and Means
Staufenberg, C. W. Jr.	Automatic Battery Charger
Taylor, H. P.	Tachometer Stabilization
Ursch, R. R.	Heat Conductor
Weil, T. A.	Choke

Committee on Magnetic Amplifiers

D. L. McMURTRIE
Wayland Laboratory



The Raytheon Committee on Magnetic Amplifiers brings together representatives of the several Company divisions concerned with one phase or another of magnetic amplifier development and application. In its general meetings the Committee discusses and exchanges information on the status of magnetic amplifier activities throughout the Company. In its technical sessions the Committee reviews specific topics in the magnetic amplifier field (e.g. the application of magnetic amplifiers in servomechanisms or a-c line regulators, etc.) generally opening with a prepared talk followed by questions and discussions. The Committee meets at least once every three months, its regularly scheduled meeting dates being the first Tuesday of Feb., May, Aug., and November. Committee members may invite guests interested in the topic at hand to attend its technical sessions. Meeting notices now appear in the Raytheon *ELECTRONIC PROGRESS*, and any Company personnel who find an announced topic of particular interest should feel free to contact the Committee chairman or any of the members for an invitation to attend.

The Committee was established almost two years ago at a time when several of the Company's departments had become active in the development and application of magnetic amplifiers following on the heels of dramatically new magnetic materials and circuit techniques. Since that time the Committee has well served its purpose as a forum for the exchange of ideas and close acquaintance of workers in the field. The Committee is anxious to make information on magnetic amplifier activity available on an even more widespread basis in order that these highly reliable devices should find their maximum utility. In the near future the Committee will distribute summaries of the activity in this field carried on by departments throughout the Company.

It is not possible in the space of this brief article to review the status of magnetic amplifier activity throughout the Company. Future issues of *ELECTRONIC PROGRESS* may be expected to report upon the more important of these activities. It can be pointed out, however, that the Transformer Division has been active for many years in the application of magnetic amplifiers to a-c line regulators and d-c battery chargers. The Division also provides stocks of magnetic materials and the facilities for winding reactors of all types. The Research Division has been active for some time in investigating saturable reactor phenomena. The Wayland Lab., Missile Systems and Commercial Divisions are all active in developing magnetic amplifiers for a wide variety of applications including d-c power supply regulators, servo amplifiers, bistable switching circuits, and others. Of particular concern currently are the possibilities inherent in circuitry combining magnetic amplifiers and transistors. Throughout the Company, magnetic amplifier activity is widespread and increasing, and it is the role of the Raytheon Committee on Magnetic Amplifiers to give the support to those activities that comes from information freely, correctly, and vigorously exchanged.

The Magnetic Amplifier — What It Is — How It Operates

If an iron-cored reactor is placed in series with an a-c voltage source and a load, the flow of energy to the load can be controlled by passing current through auxiliary reactor windings and thereby controlling the degree of flux saturation in the iron core. When the core is unsaturated, the reactor impedance is high and little energy goes to the load. When the core is saturated, the impedance is low and much more energy goes to the load. This process is the basis of all magnetic amplifier operation.

A single reactor in series with a power source and a load is not practical since a substantial power frequency voltage is induced in the control winding. Combinations of two or more reactors and rectifiers minimize this difficulty and are used to obtain magnetic amplifiers with power gains in the millions. In most cases, unfortunately, high gain is accompanied by long response times (the two are proportional in most types of magnetic amplifiers), but some types of magnetic amplifiers feature moderate power gains (up to a few hundred) with single cycle response. Note that an a-c power source is always required and that a magnetic amplifier is essentially a modulator or carrier amplifier with a minimum response time of one cycle of the carrier.

The prime virtues of magnetic amplifiers are, of course, reliability and ruggedness. With conservatively rated reactors and dry rectifiers, a magnetic amplifier has a life expectancy commensurate with high quality transformers — a life measured in terms of decades rather than months or years.

Raytheon Facilities

Bedford Flight Facility

M. A. WALKER
Missile Systems Division

The Raytheon flight facility at Bedford has assumed increasing importance in Company operations in recent years. The hangar and apron space at Bedford Airport were acquired from Harvard University in 1946 for use in the research and development programs being conducted by the division of Raytheon then designated as Laboratory 16. Since that time, the flight facilities have been expanded to keep pace with the growth of the laboratory which has since become the Missile Systems Division. Now under the direction of Chief Test Pilot George E. Bottjer, the Flight Facilities Department is playing a vital role in support of development programs in the missile and radar field. Flight testing, prototyping and mock-up of airborne weapons systems, aircraft maintenance and executive transport are all activities in which the department is engaged.

The mission of the department requires the possession of varied types of aircraft and the equipment and personnel required to service them. Presently on hand are several types of military aircraft, most of which have been procured on bailment under various service contracts. These include four Douglas F3D Skyknight interceptors, one North American F86F Sabrejet Fighter, two McDonnell F2H Banshee interceptors, one Convair C-131 transport, and one Raytheon-owned Martin B-26 Marauder. Pride of the department is a McDonnell F3H Demon, a supersonic all-weather interceptor which has recently been assigned to Raytheon. All of these aircraft are constantly employed in the flight-testing of airborne weapon systems being developed by Raytheon. They are also used where necessary in the evaluation of ground based electronic equipment.

For transportation purposes, the department utilizes a twin-engined Beechcraft cabin plane and two light Beechcraft Bonanzas. These planes are used to transport executives, engineering personnel and materials to remote locations when the lack of time or commercial facilities makes it necessary. For example, many flights are made to White Sands Proving Grounds, a center of missile test activity.

Perhaps the greatest asset of the department is its personnel who are, in general, highly trained specialists. The staff includes five test pilots who are well experienced in the operation of military and civilian aircraft, all having served in World War II or Korea. Twenty-five CAA-rated aircraft mechanics are responsible for the maintenance of the flying equipment, and the modification of aircraft to carry experimental electronic systems. The installation of these systems is accomplished by six electronic technicians who also assist Project Engineers in developmental tests. The remainder of the group is composed of personnel who provide the services required for the efficient performance of the department's mission. The vigilance with which the group has carried out its responsibilities is reflected in the success of the department's flight test programs and its excellent safety record. In ten years of operation, during hundreds of flights in all types of weather, not one major accident has occurred.

A major contribution of the Flight Facilities Department is its activity in public relations. Ray-

theon aircraft and pilots have participated in many public exhibitions of military equipment on occasions such as Armed Forces Day. On a recent occasion, the F3H Demon was one of the chief attractions at a show held at the Weymouth Naval Air Station.

As for the future of the department, it is apparent that its role in Company operations will assume greater significance as Raytheon broadens its activity in the field of airborne electronics. Long range plans for expanding the department's facilities are now being studied.

McDonnell F3H "Demon"

Publications & Papers

"A Rugged, Tunable, Thermally Stable X-Band Beacon Magnetron"

C. J. ORLEBEKE

Second Annual Technical Meeting of the I.R.E. Professional Group on Electron Devices

Washington, D. C., October 26, 1956

Abstract: Packaged magnetrons, until a few years ago, had their weight reported in pounds. As the demand for miniaturization increased, however, it became desirable to incorporate ruggedness, tunability, and thermal stability into a magnetron weighing only a few ounces. This paper describes the development and achievement of such a tube; an X-band beacon magnetron, cylindrically shaped, which weighs less than six ounces. Particular attention will be paid to those phases of miniaturization which required revision of traditional design approaches.

"Quality Control and Guided Missile Tube Reliability"

H. H. HOYLE

National Electronics Conference

Chicago, Illinois, October 1-3, 1956

Abstract: Need for increased reliability of electron tubes for guided missile programs requires reconsideration of philosophy and method of manufacture. Analysis of field information has indicated that failures in equipment can be broken into "Catastrophic" and wear-out type of failures. Examination of the defects has indicated that many of the failures could have been eliminated by changes in material, design, workmanship and close control of the manufacturing operation.

This paper describes a Quality Control Program designed to eliminate the cause of defects, both actual and potential, at their source, that is, during the time of manufacture. The course of the program is described and results shown to illustrate improvements that have resulted in increased missile tube reliability.

"A Survey of Physico-Chemical Applications of Ultrasonics"

NORMAN E. GIBBS

Technical Report R-11, February 24, 1956

Abstract: The growth of "Sonochemistry" extends over some twenty-five years and comprises both basic investigations and many applications to physical processing of materials.

Cavitation is responsible for the chemical effects induced by ultrasonic irradiation in liquids. A similarity to catalytic chemistry exists and often seemingly minor variables must be carefully controlled in order that the desired reactions may be promoted.

Ultrasonics is a valuable tool to the chemist in fundamental determinations of physical constants, in plant and laboratory processing, and for measurement and control.

The chemical reactions promoted by ultrasonics are varied and are particularly valuable for organic preparation and synthesis, and high polymer research. There are fields in unexplored reaction types which appear promising.

A selected bibliography is appended.

"The Spacistor, A New Class of High-Frequency Semiconductor Devices"

H. STATZ and R. A. PUCEL

Technical Report R-13, July 1, 1956

Abstract: New devices are considered in which electrons or holes are directly injected into space-charge regions of reverse biased junctions avoiding the diffusion of carriers through field-free regions. The case considered is one in which the junction is biased at a voltage such that the injected carriers are multiplied by the avalanche process. A device of this type is called a spacistor at Raytheon, It is shown that negative resistance devices and amplifying devices may be constructed. The difficulty is the accumulation of the generated carriers in front of the emitting contact. Experimentally, it has been found that this accumulation of carriers results in the spontaneous relaxation type oscillations of a transistor-like structure operated at collector voltages greater than the punch-through voltage. It is suggested that the accumulation effect may be diminished by the use of small emitters and magnetic fields.

"A Long-Life Nickel Cathode for Use at High Emission Densities"

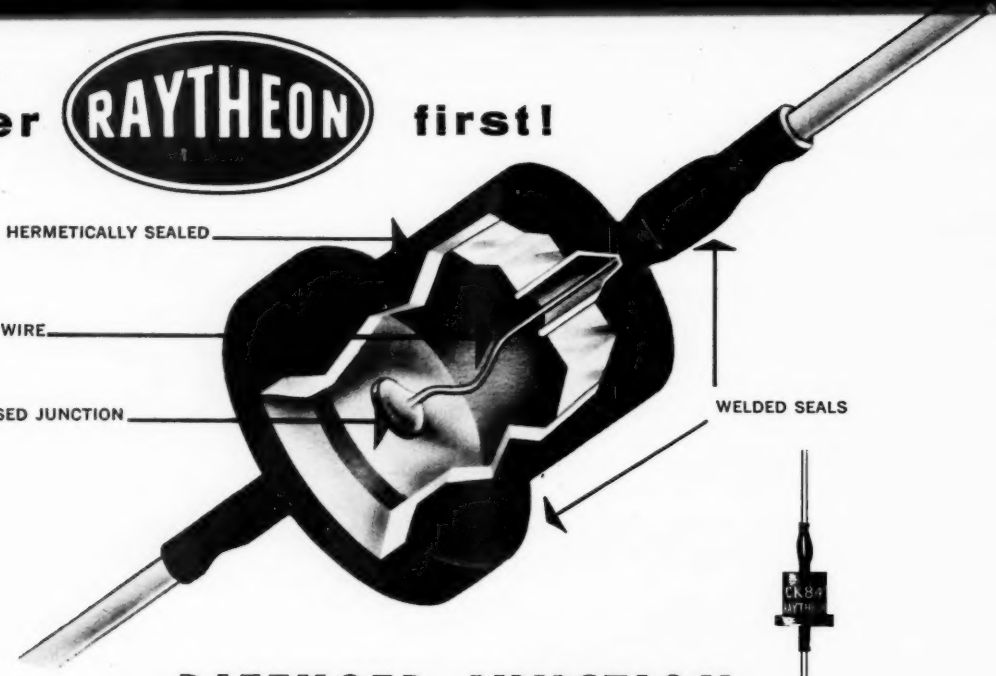
JOSEPH APELBAUM

Third Annual Tube Techniques Conference

New York City, September 14, 1956

Abstract: Considerable work has been done on an impregnated type of nickel cathode which shows promise in those applications requiring high emission density and long life. This paper gives a detailed description of the cathode and discusses the method of fabrication. Several forms of the cathode are possible depending upon the nature of the application. Each form has been evaluated, and the relative merits are presented. The method of testing the emission of developmental cathodes is related. Typical values of emission which can be obtained as well as figures on cathode life are included for a variety of operating conditions. The present status of the project is summarized, and possible future studies mentioned. Several possible uses of the cathode in tube applications are suggested.

another RAYTHEON first!



Actual Size

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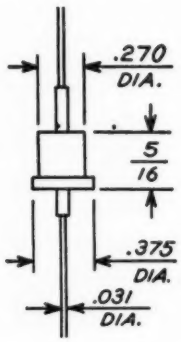

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Type	Peak Inverse Volts*	Forward Current** milliamperes 100°C	150°C	Forward Volts*** at 350 mA 100°C	Reverse Current*** (max.) mA at rms volts 100°C
CK840	100	350	100	0.75	0.2 at 70
CK841	200	350	100	0.75	0.2 at 140
CK842	300	350	100	0.75	0.2 at 210
CK843	400	350	100	0.75	0.2 at 280
CK844	500	350	100	0.75	0.2 at 350
CK845	600	350	100	0.75	0.2 at 420

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**Into inductive or resistive load

***Averaged over one complete cycle

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